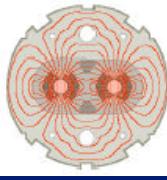


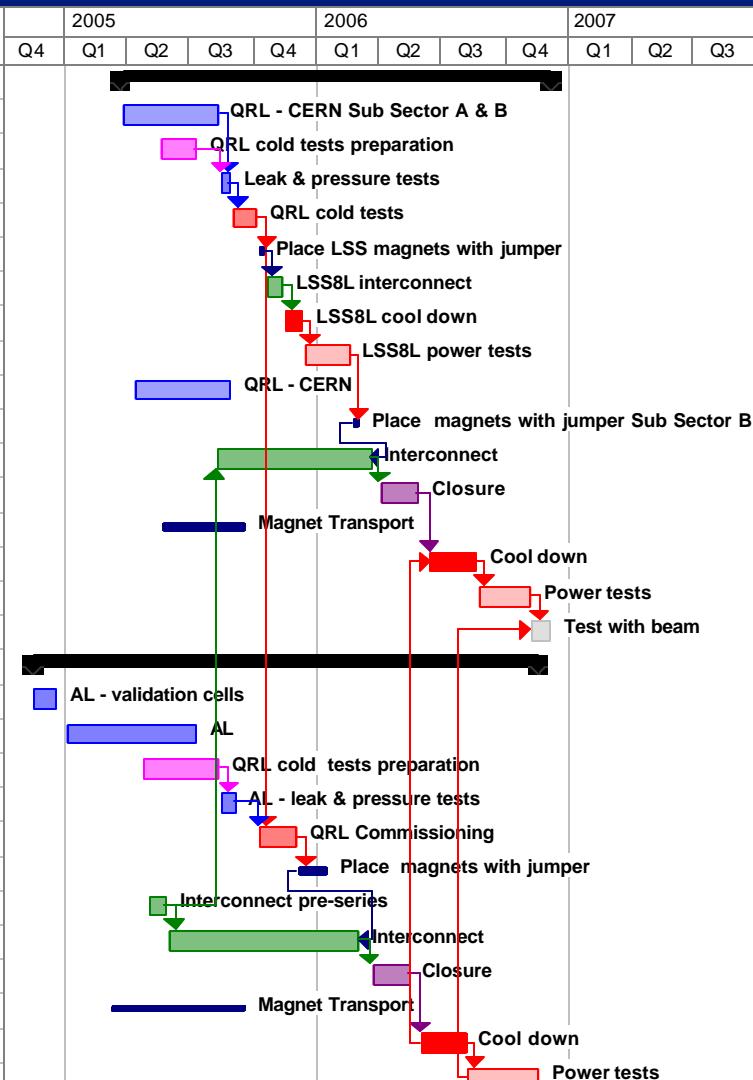
LHC Status and Commissioning Strategy

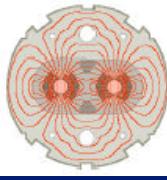
**R. Bailey
AB LHC Operations**



Installation planning Sectors 7-8 & 8-1

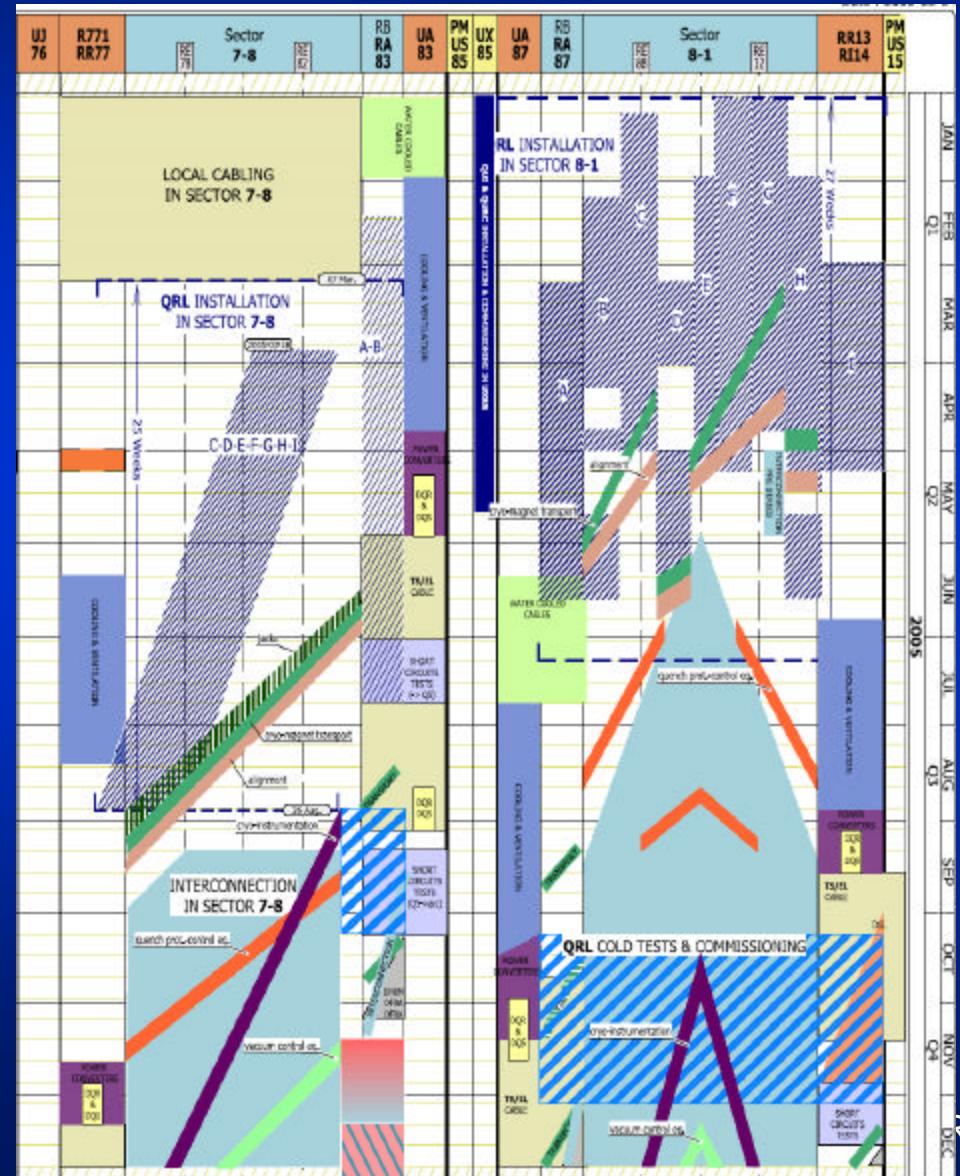
ID	Task Name	Duration	2004		2005				2006				2007			Q4
			Start	Finish	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
1	Sector 7-8	436 days	Mon 21.03.05	Mon 04.12.06												
2	QRL installation	105 days	Mon 21.03.05	Fri 12.08.05												
3	QRL cold tests preparation	40 days	Mon 16.05.05	Fri 08.07.05												
4	QRL leak & pressure tests	10 days	Mon 15.08.05	Fri 26.08.05												
5	QRL cold tests	30 days	Mon 29.08.05	Fri 07.10.05												
6	LSS magnets with jumper	5 days	Mon 10.10.05	Fri 14.10.05												
7	Magnet interconnect	20 days	Mon 17.10.05	Fri 11.11.05												
8	Cool down	20 days	Mon 14.11.05	Fri 09.12.05												
9	LSS8L power tests	40 days	Mon 12.12.05	Fri 17.02.06												
10	QRL installation	100 days	Mon 11.04.05	Fri 26.08.05												
11	LSS magnets with jumper	10 days	Mon 20.02.06	Fri 03.03.06												
12	Magnet interconnect	150 days	Mon 08.08.05	Fri 17.03.06												
13	Interconnect closure	40 days	Mon 03.04.06	Fri 26.05.06												
14	Magnet transport	85 days	Mon 23.05.05	Fri 16.09.05												
15	Cool down	50 days	Mon 12.06.06	Fri 18.08.06												
16	Power tests	56 days	Mon 21.08.06	Mon 06.11.06												
17	Sector tests	20 days	Tue 07.11.06	Mon 04.12.06												
18	Sector 8-1	505 days	Mon 15.11.04	Fri 17.11.06												
19	QRL validation cells	25 days	Mon 15.11.04	Fri 17.12.04												
20	QRL installation	135 days	Mon 03.01.05	Fri 08.07.05												
21	QRL test preparation	80 days	Mon 25.04.05	Fri 12.08.05												
22	QRL leak & pressure tests	15 days	Mon 15.08.05	Fri 02.09.05												
23	QRL commissioning	40 days	Mon 10.10.05	Fri 02.12.05												
24	Magnets with jumper	20 days	Mon 05.12.05	Fri 13.01.06												
25	Magnet interconnect	20 days	Mon 02.05.05	Fri 27.05.05												
26	Magnet interconnect	190 days	Mon 30.05.05	Fri 03.03.06												
27	Interconnect closure	40 days	Mon 20.03.06	Fri 12.05.06												
28	Magnet transport	140 days	Mon 07.03.05	Fri 16.09.05												
29	Cool down	50 days	Mon 29.05.06	Fri 04.08.06												
30	Power tests	75 days	Mon 07.08.06	Fri 17.11.06												



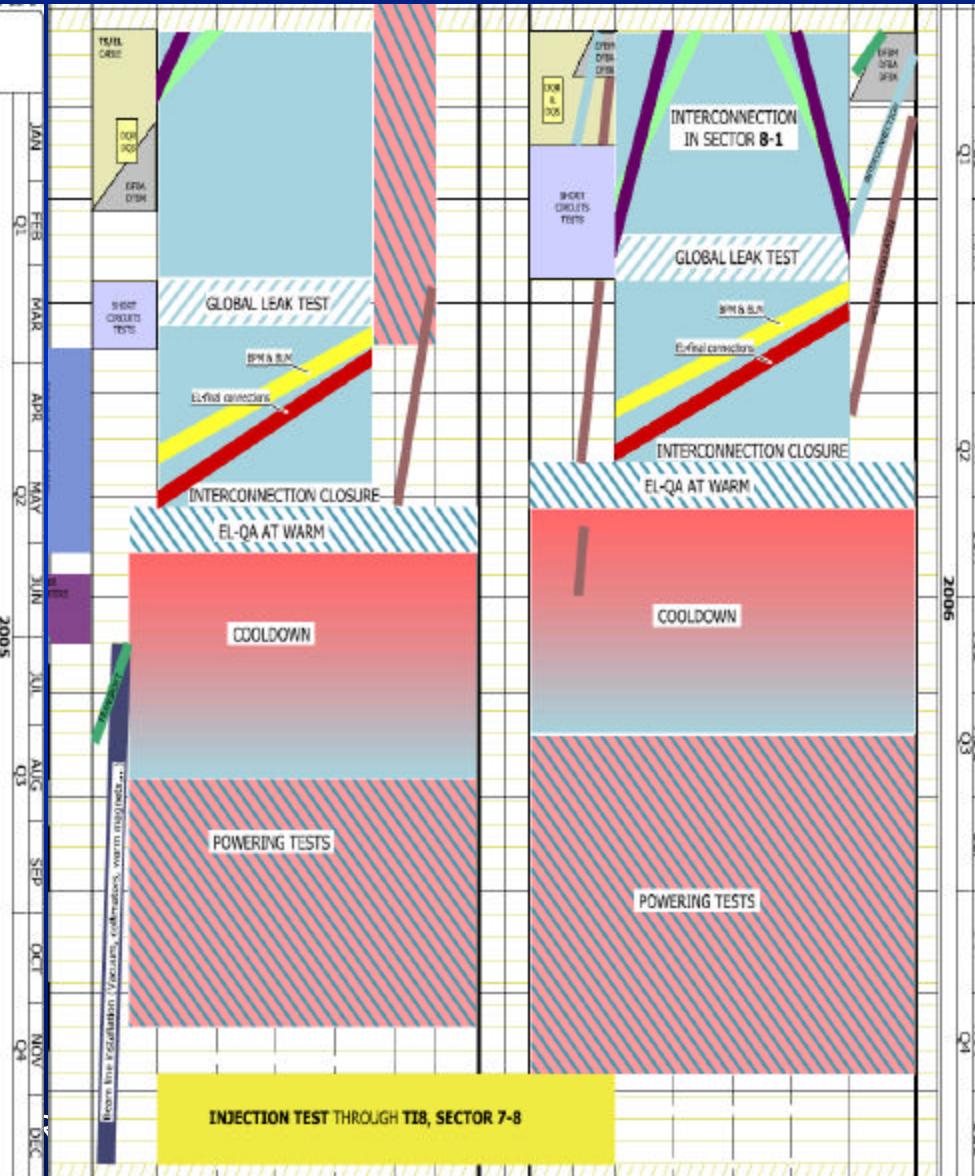


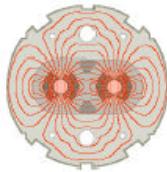
Detailed planning for 7-8 and 8-1

2005

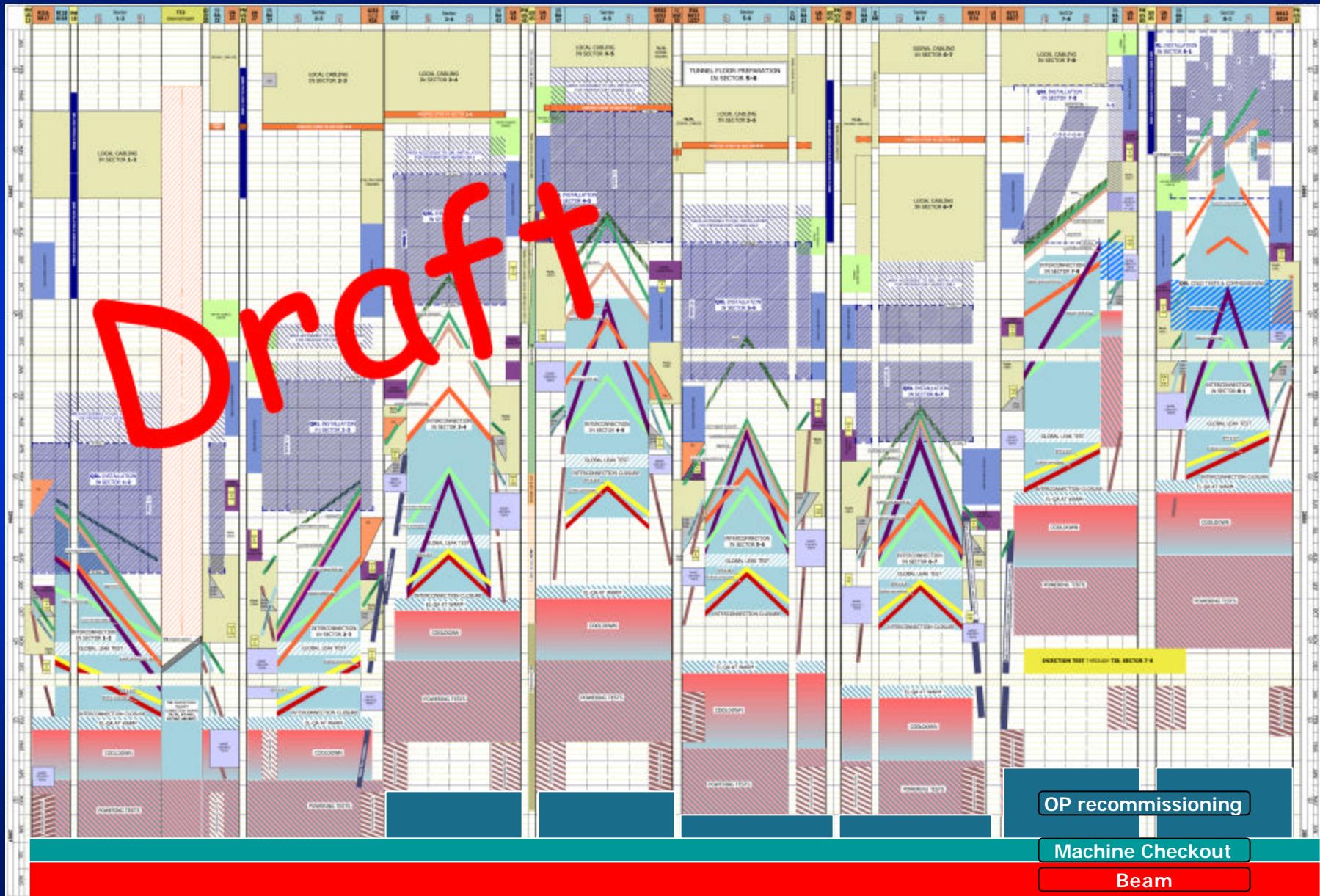


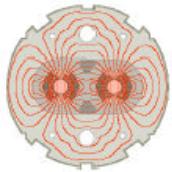
2006





Overall planning summary





Commissioning strategy

- Eventual goal: luminosity of $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$

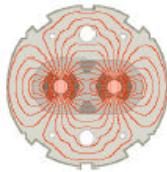
$$L = \frac{N^2 k_b f g}{4 p e_n b^*} F$$

Nominal Parameters

Beam energy (TeV)	7.0
Number of particles per bunch	$1.15 \cdot 10^{11}$
Number of bunches per beam	2808
Crossing angle (mrad)	285
Nomalised transverse emittance (mm rad)	3.75
Beta function at IP 1, 2, 5, 8 (m)	0.55,10,0.55,10

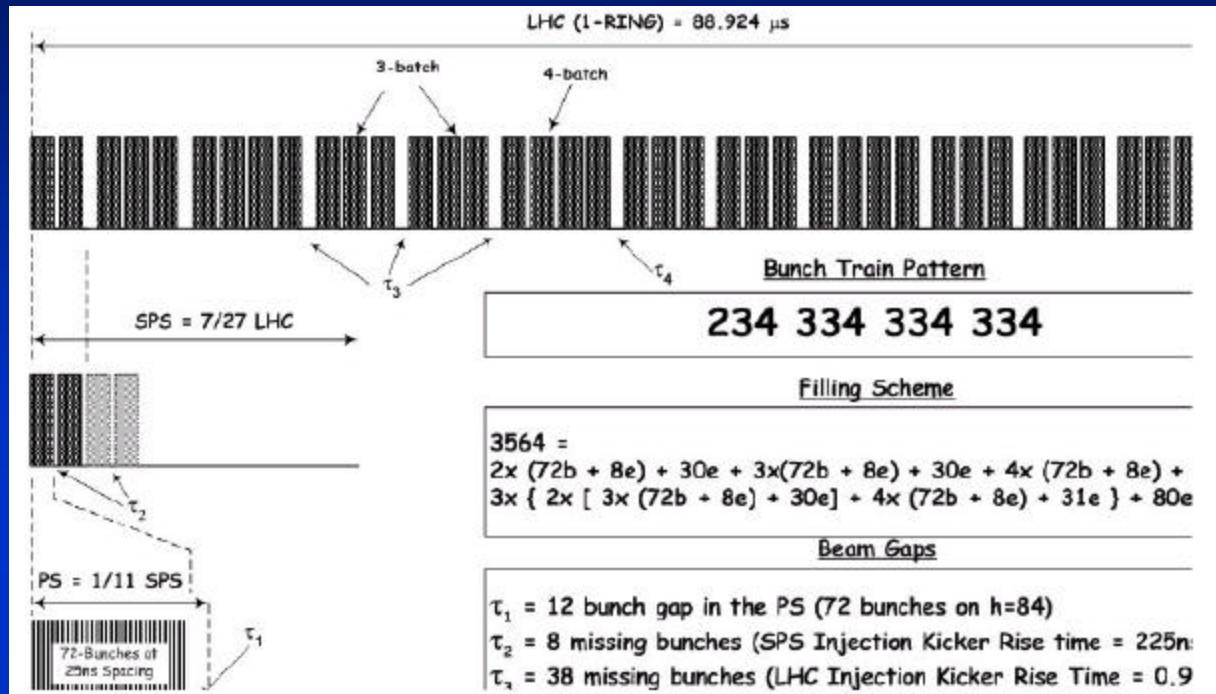
Related parameters

Luminosity in IP 1 & 5 ($\text{cm}^{-2} \text{ s}^{-1}$)	10^{34}
Luminosity in IP 2 & 8 ($\text{cm}^{-2} \text{ s}^{-1}$)	$\sim 5 \cdot 10^{32}$
Transverse beam size at IP 1 & 5 (mm)	16.7
Transverse beam size at IP 1 & 5 (mm)	70.9
Stored energy per beam (MJ)	362

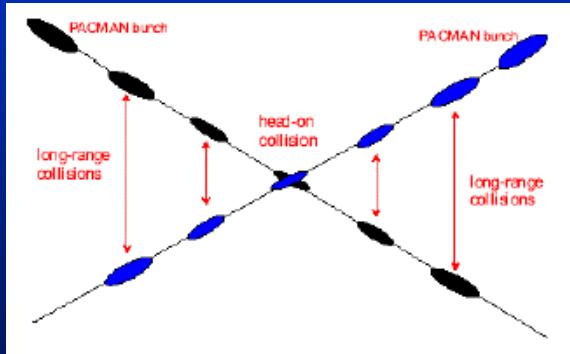


2808 is a lot of bunches per beam

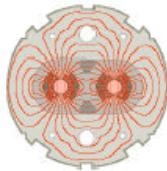
- Filling scheme requires 12 SPS cycles per beam
 - Each with 2,3 or 4 batches of 72 bunches



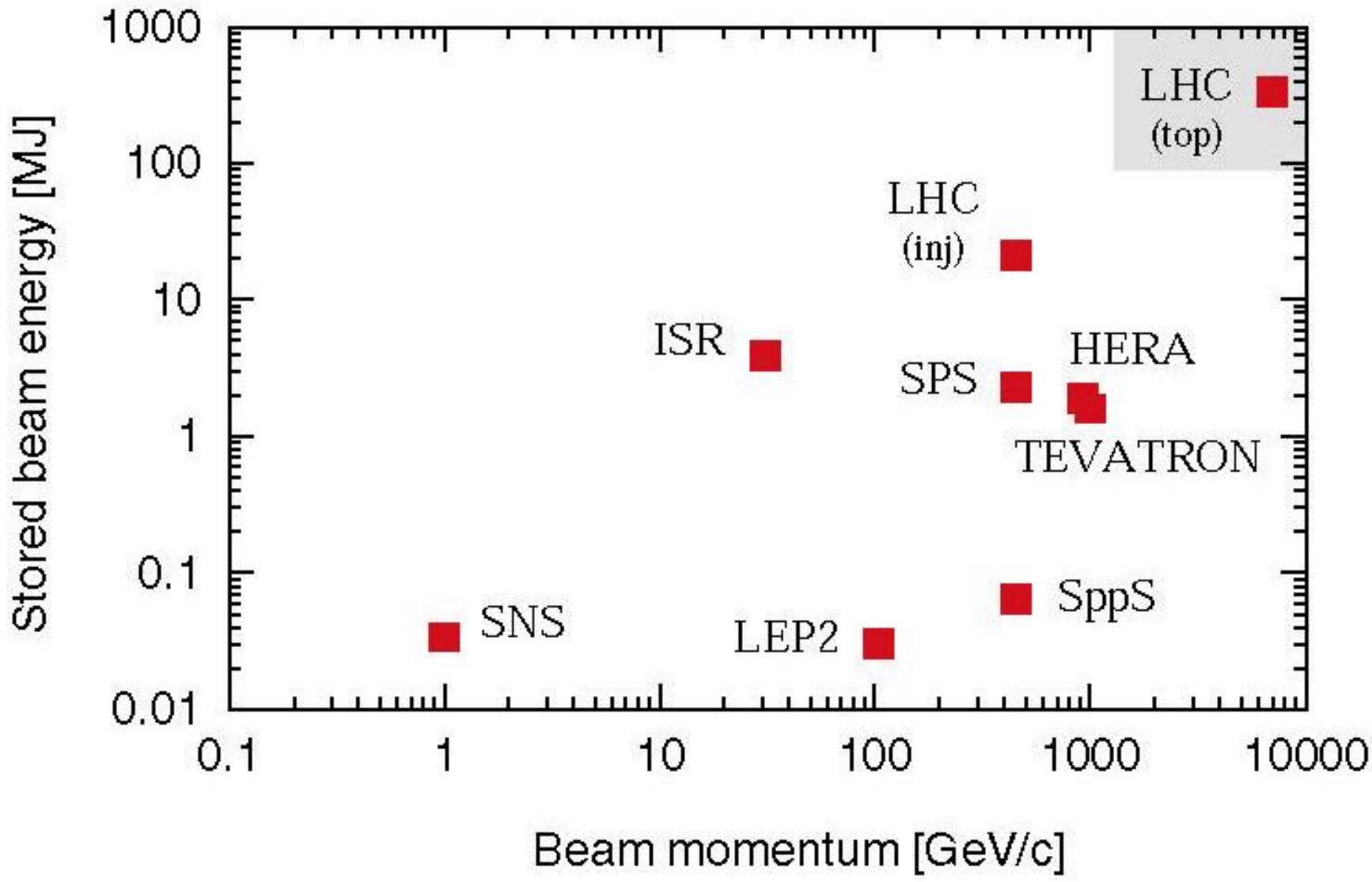
- Crossing angle needed

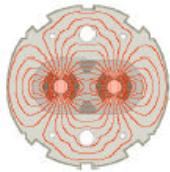


- Emittance conservation with 10^{11} protons per bunch through
 - Injecting
 - Ramping
 - Squeezing to 0.55m
- This is going to take us a little while !!!!!!!!



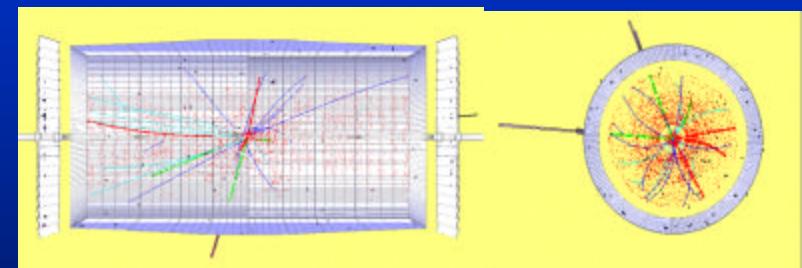
362MJ is a lot of beam energy to handle

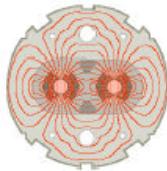




So how to get there ?

- **Avoid quenches (and damage)**
 - Reduce total current to reduce stored beam energy
 - Lower i_b
 - Fewer bunches (we have 25ns 50ns 75ns spacing available)
 - Higher b^* to avoid problems in the (later part of) the squeeze
 - Reduce energy to get more margin
 - Against transient beam losses
 - Against magnet operating close to training limit
- Both machine and experiments will have to learn how to stand running at nominal intensities
- An early aim is to find a balance between robust operation and satisfying the experiments
 - Maximize integrated luminosity
 - Minimize event pile-up (to event + 2)

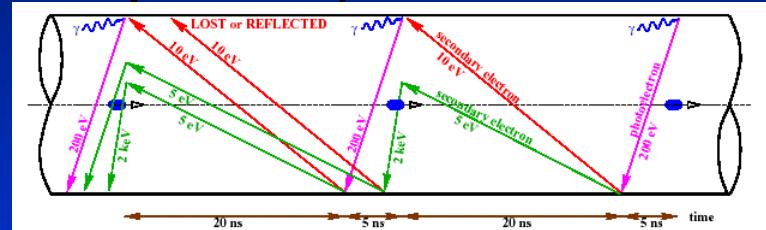




Other considerations

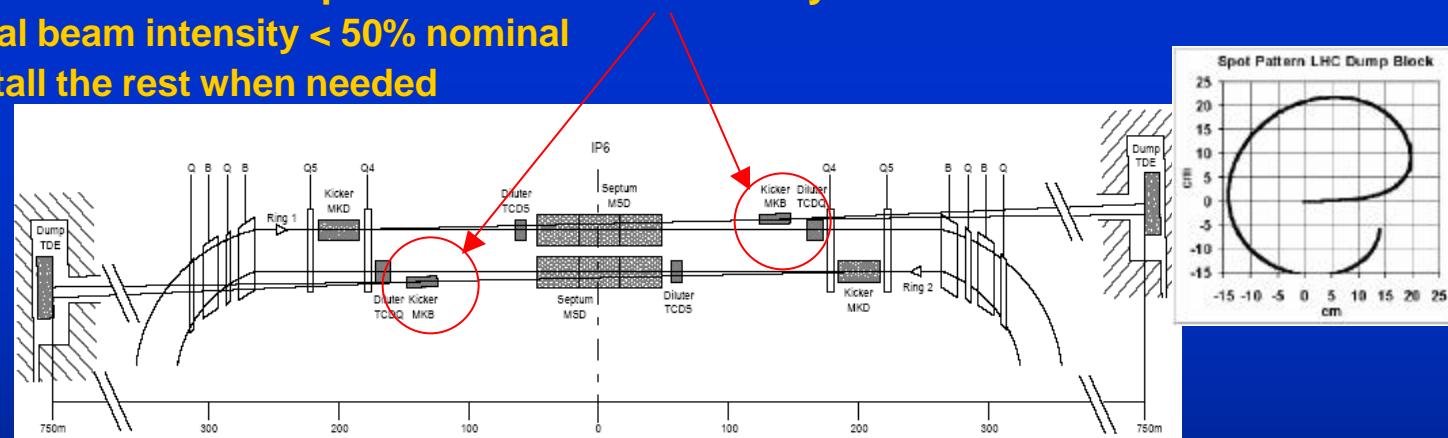
- Electron cloud (LHC simulations and SPS experience)

- $i_b < 35\%$ nominal for 25ns spacing
- $i_b \sim \text{nominal}$ for $> 50\text{ns}$



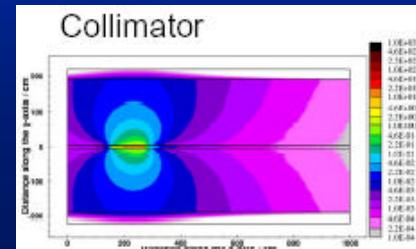
- With lower currents in mind, two machine systems will be staged

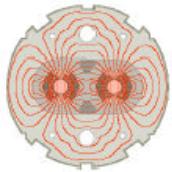
- Only 8 of 20 beam dump dilution kickers initially installed
 - Total beam intensity $< 50\%$ nominal
 - Install the rest when needed



- Collimators (robustness, impedance and other issues)

- Phased approach
- Run at the impedance limit during phase I
 - Lower currents
 - Higher b^*





Proposal for early proton running

Phase I collimators and partial beam dump

1. Pilot physics run with few bunches

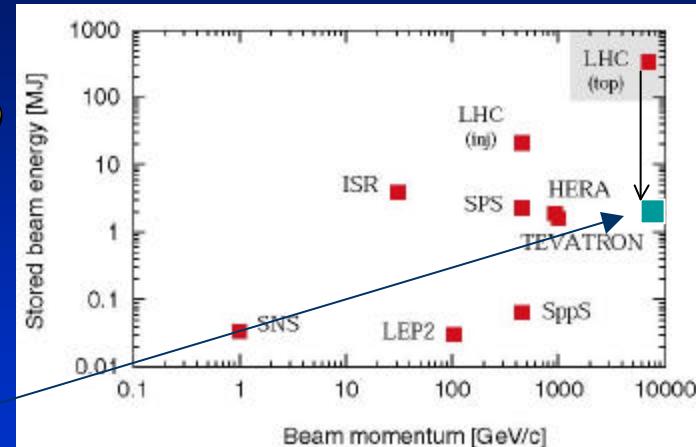
- No parasitic bunch crossings
- Machine de-bugging no crossing angle
- 43 bunches, unsqueezed, low intensity
- Push performance (156 bunches, partial squeeze, higher intensity)

2. 75ns operation

- Establish multi-bunch operation
- Relaxed machine parameters (squeeze and crossing angle)
- Push squeeze and crossing angle

3. 25ns operation with Phase I collimators + partial beam dump

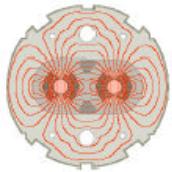
- Needs scrubbing for higher intensities ($i_b > 3 \cdot 10^{10}$)



Phase II collimators and full beam dump

25ns operation

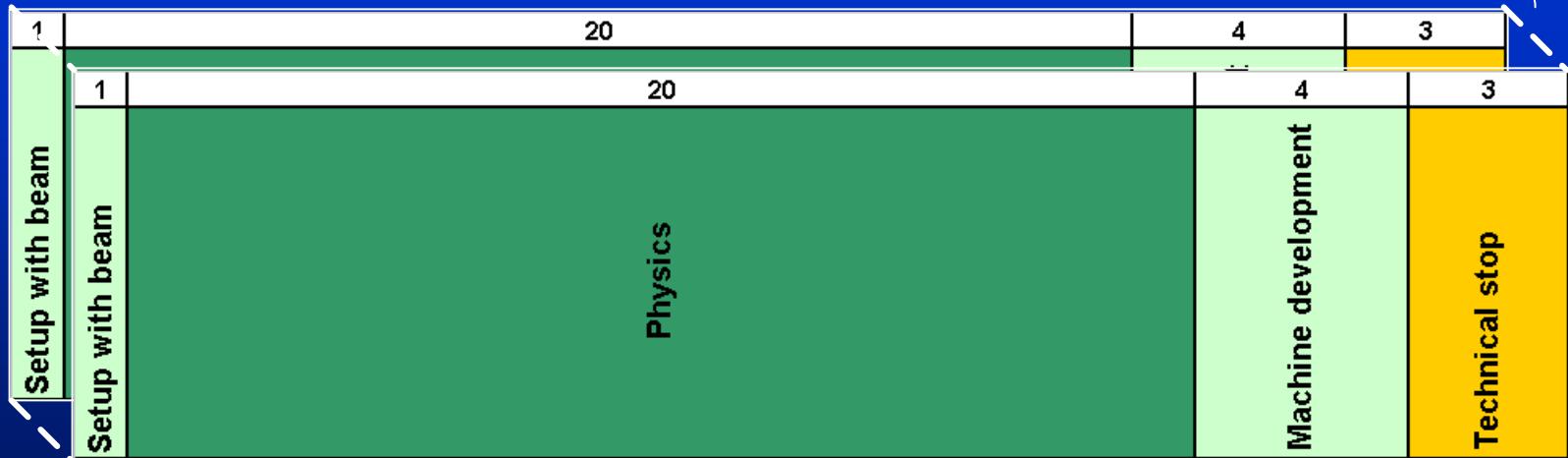
- Push towards nominal performance

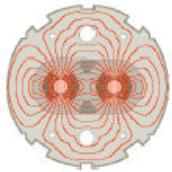


Breakdown of a year

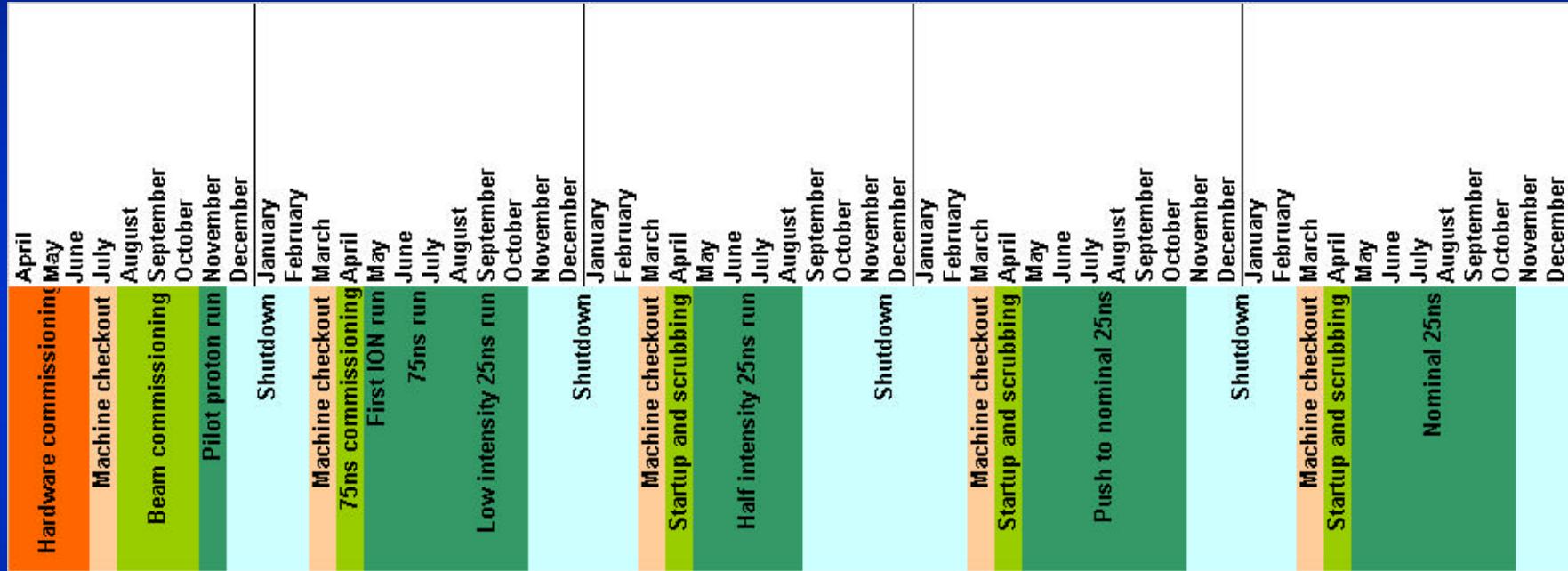


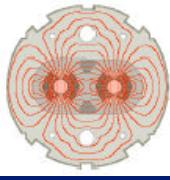
7





So the first years will look something like ...



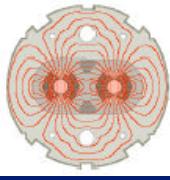


Stage 1 – pilot run luminosities

$$L = \frac{N^2 k_b f g}{4 p e_n b^*} F$$

- No squeeze to start
- 43 bunches per beam (some displaced in one beam for LHCb)
- Around 10^{10} per bunch
- Push one or all of
 - 156 bunches per beam (some displaced in one beam for LHCb)
 - Partial optics squeeze
 - Increase bunch intensity

Beam energy (TeV)	6.0, 6.5 or 7.0	6.0, 6.5 or 7.0	6.0, 6.5 or 7.0
Number of bunches per beam	43	43	156
b* in IP 1, 2, 5, 8 (m)	18,10,18,10	2,10,2,10	2,10,2,10
Crossing Angle (mrad)	0	0	0
Transverse emittance (mm rad)	3.75	3.75	3.75
Bunch spacing (ms)	2.025	2.025	0.525
Bunch Intensity	$1 \cdot 10^{10}$	$4 \cdot 10^{10}$	$4 \cdot 10^{10}$
Luminosity IP 1 & 5 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 3 \cdot 10^{28}$	$\sim 5 \cdot 10^{30}$	$\sim 2 \cdot 10^{31}$
Luminosity IP 2 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 6 \cdot 10^{28}$	$\sim 1 \cdot 10^{30}$	$\sim 4 \cdot 10^{30}$

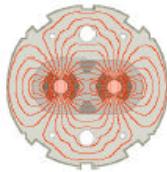


Stage 2 – 75ns luminosities

$$L = \frac{N^2 k_b f g}{4 p e_n b^*} F$$

- Partial squeeze and smaller crossing angle to start
- Luminosity tuning, limited by event pileup
- Establish routine operation in this mode
- Move to nominal squeeze and crossing angle
- Increase bunch intensity ?
- Tune IP2 and IP8 to meet experimental needs

Beam energy (TeV)	6.0, 6.5 or 7.0	6.0, 6.5 or 7.0	6.0, 6.5 or 7.0
Number of bunches per beam	936	936	936
b * in IP 1, 2, 5, 8 (m)	2,10,2,10	0.55,10,0.55,10	0.55,10,0.55,10
Crossing Angle (mrad)	250	285	285
Transverse emittance (mm rad)	3.75	3.75	3.75
Bunch Intensity	$4 \cdot 10^{10}$	$4 \cdot 10^{10}$	$9 \cdot 10^{10}$
Luminosity IP 1 & 5 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 1 \cdot 10^{32}$	$\sim 4 \cdot 10^{32}$	$\sim 2 \cdot 10^{33}$
Luminosity IP 2 & 8 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 2 \cdot 10^{31}$	$\sim 2 \cdot 10^{31}$	$\sim 1 \cdot 10^{32}$

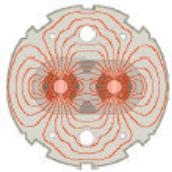


Stage 3 – 25ns luminosities

$$L = \frac{N^2 k_b f g}{4 p e_n b^*} F$$

- Production physics running
 - Start with bunch intensities below electron cloud threshold
 - Scrubbing run (1-2 weeks)
 - Increase bunch intensities to beam dump & collimator limit
 - Install beam dump kickers
 - Install phase II collimators
 - Increase bunch intensities towards nominal
 - Tune IP2 and IP8 to meet experimental needs
- Long shutdown (6months)

Beam energy (TeV)	6.0, 6.5 or 7.0	6.0, 6.5 or 7.0	7.0
Number of bunches per beam	2808	2808	2808
b * in IP 1, 2, 5, 8 (m)	0.55,10,0.55,10	0.55,10,0.55,10	0.55,10,0.55,10
Crossing Angle (mrad)	285	285	285
Transverse emittance (mm rad)	3.75	3.75	3.75
Bunch Intensity	$3 \cdot 10^{10}$	$5 \cdot 10^{10}$	$1.15 \cdot 10^{11}$
Luminosity IP 1 & 5 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 7 \cdot 10^{32}$	$\sim 2 \cdot 10^{33}$	10^{34}
Luminosity IP 2 & 8 ($\text{cm}^{-2} \text{s}^{-1}$)	$\sim 4 \cdot 10^{31}$	$\sim 1 \cdot 10^{32}$	$\sim 5 \cdot 10^{32}$



Commissioning for the pilot run

- Mike's talk